Technologies for sustainable potato production: improving seed health and vigour

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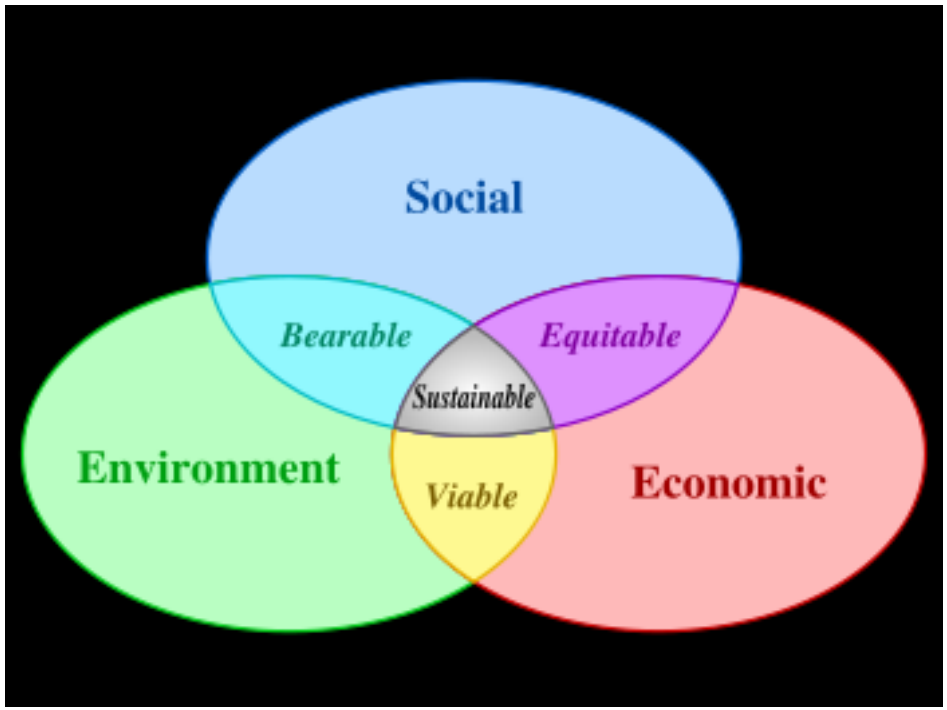
Seed Potato Biotechnology

Sustainability

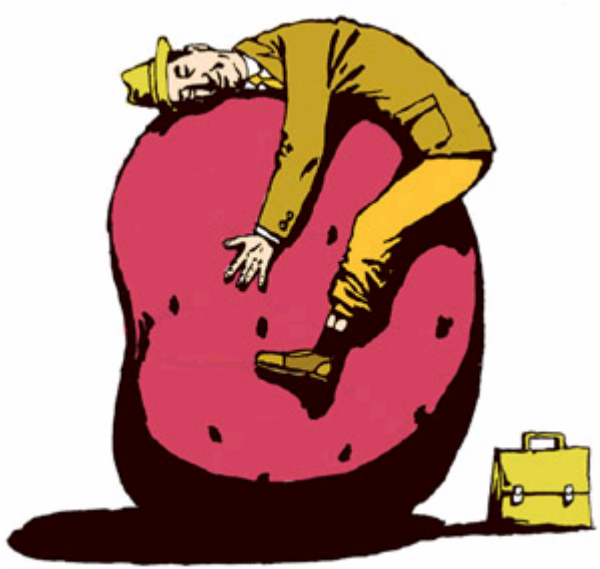
Scheme of sustainablity

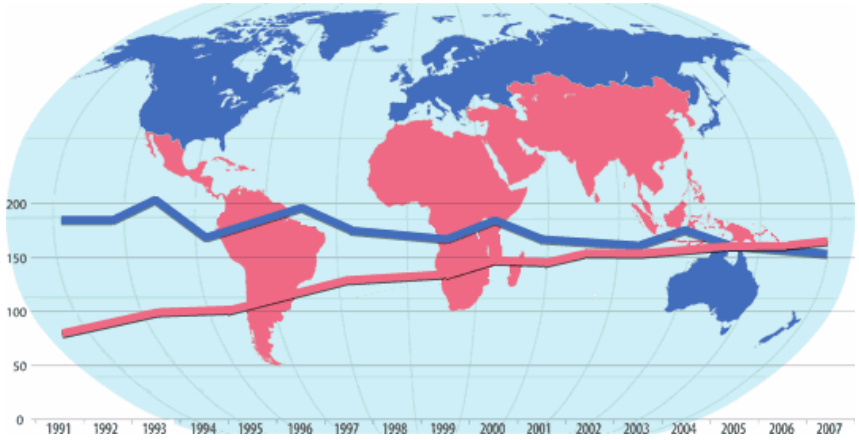


Adapted from Johann Dréo, 2006
(http://www.sustainabilityportal.info)

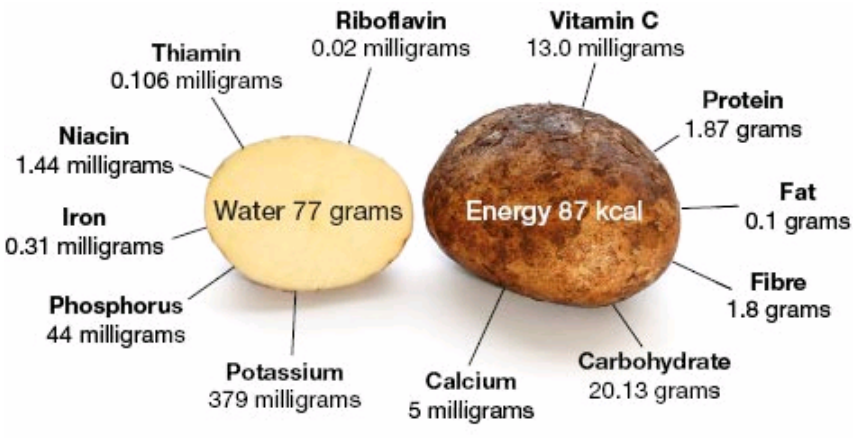
Potato: food of the future

Almost a third of all potatoes is now harvested in China and India.





(http://www.potato2008)



Sustainable Potato Production

- Healthy and
- Physiologically Sound seeds

Limiting factors

- Potato suffers from a wide range of diseases

  Bacteria

  Viruses

  Fungi

Late Blight of Potato
One of the tragic experiences in the history of Plant Pathology

The Great Irish Famine of the 1840s

Death and migration of millions of people

Late blight of potato: symptoms and sign

Leaf lesions

http://:www.uidaho.edu

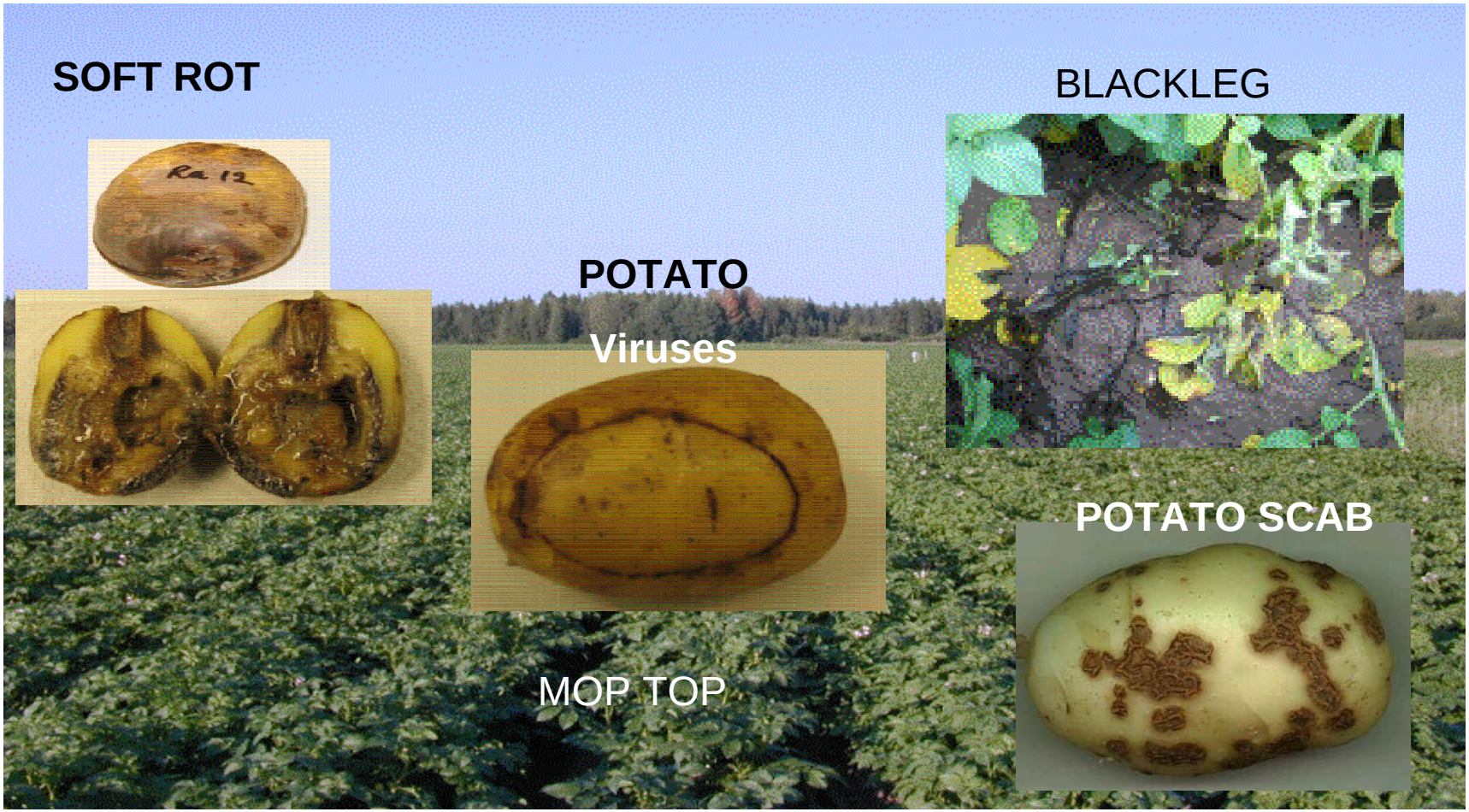
Close-up of underside of lesion showing cottony, white mold growth of the late blight fungus on potato leaf.

http://ohioline.osu.edu

Late Blight of potato: The unsolved disease problem even in the 21st century

- Production depends on heavy fungicide use
- Risk of resistant strains of the pathogen and withdrawal of chemicals
- Costly and pose threat to the environment

Other diseases of economic importance



(Y. Degefu, MTT Ruukki)

Agrobiotechnology in seed potato Production

- A pioneer and umbrella agrifood project of the Bioforum Oulu
- Multidisciplinary research focused on
  - Potato Pathology
  - Potato Physiology
  - Profitability

Application of Modern Technology

Some success stories of Potato Biotechnology

✓ Potato resistant to late blight (*Phytophthora infestans*) by engineering a gene from Mexican wild potato

✓ Accleration of potato tuber sprouting by expression of a bacterial pyrophosphatase (Dormancy in transgenic tubers reduced by six to seven weeks compared to wild type tubers) (**Farre et al., 2001, Nature Biotechnology 19:268-272)**

✓ Freeze-thaw-stable potato starch by antisense inhibition of three starch synthase genes (**Stephen et al., 2002. Nature Biotechnology 20: 295-299**)

Biotech Potato: Potentials

Potential Impacts of Biotech Potato on Production and Income					
	Potato Production		*Production Costs*		*Net Income (€ Million)*
	Volume (million	*Value (€ Million)*	Fungiside (€ Million)	Seed Cost (€ Million)	
Austria	14	1,2	-6,3	1,1	6,4
Belgium	51	4,1	-33,9	3,1	34,9
Denmark	31	6,8	-11,8	1,9	16,7
Finland	15	1,9	-7,0	1,5	7,4
France	122	10,9	-63,2	8,1	66,0
Germany	230	16,1	-88,0	14,1	90,0
Ireland	9	1,6	-4,5	0,7	5,4
Italy	39	3,5	-13,6	3,9	13,2
Netherlands	140	12,6	-75,8	8,1	80,3
Spain	59	12,4	-10,1	5,8	16,7
Sweden	18	4,6	-8,7	1,6	11,7
United Kingdom	130	23,5	-52,6	8,2	67,9
Total	858	99,2	-375,5	58,1	416,6

Full Report WWW.ncfap.org

Molecular Diagnostics

Early and accurate detection and identification of pathogens are crucial for effective disease control

Molecular Diagnostics (detection)

- ✓ Sensitive
- ✓ Specific
- ✓ Multiplexing capability (Microarray)
- ✓ Quantitative (Real Time PCR)
- ✓ Rapid
- ✓ Requires no taxonomic expertise
- ✓ Detection at latent stage (before symptoms apear)

DIAGNOSTIC PCR

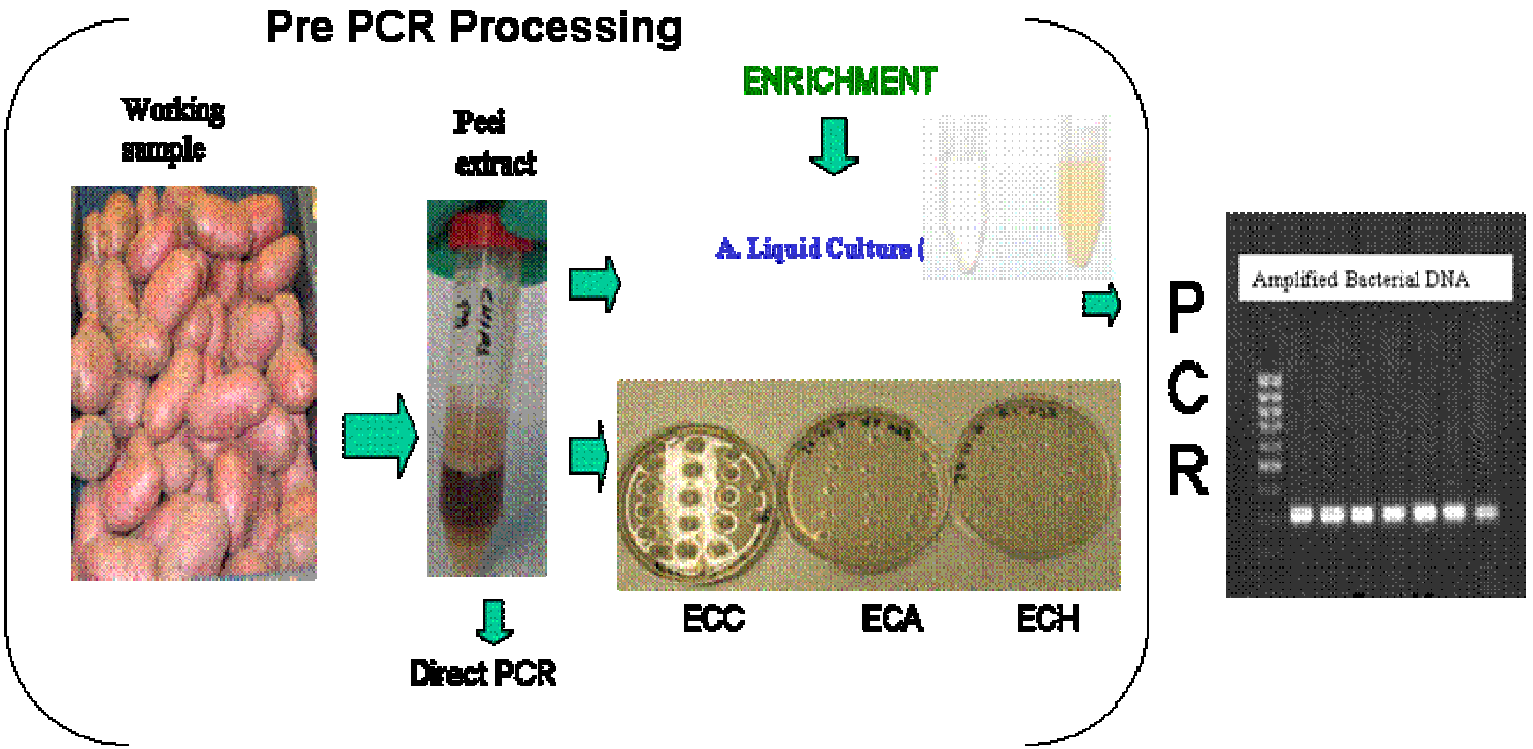


Figure. Scheme for detection of Erwinia strains in seed potatoes

(Y.Degefu, MTT Ruukki)

Improving Vigour and quality

- Tuber calcium
  - Positively impact human nutrition and agricultural production
    - boosting calcium consumption
    - disease resistance and tuber quality
    - reduced calcium fertilizer use

Genetic manipulation of potato

- Enhancing calcium content in tuber

- The calcium levels in plants can be engineered through transformation and expression of the *Arabidopsis* Ca trasporter gene (Cax1 transporter)
- **(Park et al. 2005. Journal of Agricultural and Food Chemistry 53: 5598-5603)**

  - High calcium accumulating wild species of potato
  - http://www.ars.usda.gov/is/AR/archive/mar03/gene0303/htm
    - Could make important contribution to the quality of commercial cultivars

Finland Potential source of high quality seed potato (OULU REGION)

- The High Grade status
- The Northern Vigour™ concept
- The suitable climate and soil of Oulu region
- The long history and experience of seed potato production in the region
- Incorporation of high technology in the production chain
  - Agrobiotechnology
  - IT (the ePotato)

Areas with High Grade Status granted by EU (free from dangerous diseases and pests)

- Finland: Municipalities of Liminka and Tyrnävä, Oulu Region